

**AN ASSESSMENT OF PROCESSING AND STORAGE FACILITIES IN
SELECTED LOCAL GOVERNMENTS AREA IN BENIN CITY.**

BY

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CERTIFICATION

This is to certify that this project work was carried out by ESENE-MOSES OMOYEME ISABELLA, Matriculation Number ENG2001986, of the Department of Agricultural Engineering, Faculty of Engineering, University of Benin City, Edo State, Nigeria.

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DEDICATION

I dedicate this project to God Almighty, the source of my strength, wisdom, and inspiration. Without His grace and mercy, this journey would not have been possible.

To my beloved family, whose unwavering love, prayers, and support have carried me through the highs and lows of this academic pursuit, thank you for believing in me.

To my dear sisters and close friends, your encouragement and understanding gave me the courage to keep pushing forward.

This work is also dedicated to every young woman in agricultural engineering trying to make an impact, may this be a reminder that you are capable, strong, and destined for greatness.

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ABSTRACT

This research explores the processing and storage facilities of agricultural products in Benin City, Nigeria, analyzing the challenges and effectiveness of existing systems. The study investigates the impact of inadequate storage on food security, economic growth, and waste reduction. Using a combination of surveys and observational research, data was collected from key stakeholders in the agricultural sector, including farmer, storage facility managers and consumers. The findings reveal significant gaps in infrastructure, leading to high post- harvest losses. The study highlights the need for improved preservation technologies and government intervention. Recommendations are made for sustainable storage solutions that can enhance productivity and reduce spoilage.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Agriculture remains a cornerstone of economic development and food security for many especially in sub-Saharan Africa. In Nigeria, the agricultural sector employs over 70% of the rural population and contributes significantly to the nation's GDP (NBS, 2020). Beyond just feeding the population, agriculture supports livelihoods, promotes rural development, and drives trade and industrialization. Within this broader agricultural ecosystem, post-harvest handling, including processing and storage, plays a vital role in maintaining product quality, reducing waste, and ensuring food availability across seasons (FAO, 2019).

Despite its importance, Nigeria continues to grapple with high post-harvest losses, particularly among smallholder farmers who lack access to modern processing and storage technologies. According to the Federal Ministry of Agriculture and Rural Development (FMARD, 2021), Nigeria loses between 30% to 50% of perishable agricultural produce annually due to inadequate processing and storage. These losses not only represent wasted effort, resources, and income for farmers but also contribute to food insecurity, price instability, and poverty, especially in urban and peri-urban areas.

In Benin City, the capital of Edo State, agriculture is a major activity that supports both rural and urban populations. The region is known for the production of crops such as maize, yam, cassava, plantain, vegetables, and palm produce (Edo ADP, 2020). However, many of these agricultural products are perishable and highly vulnerable to spoilage without proper post-harvest treatment. Farmers and agro-traders in Benin City often face the same recurring challenge: they produce abundantly during harvest season but suffer massive losses shortly after due to the lack of storage infrastructure and inadequate processing capacity. For instance, during the peak tomato season in Edo State, there is often a glut in the market, causing prices to crash. But just weeks later, scarcity sets in and prices soar. This boom-bust cycle is largely due to the absence of processing facilities (like tomato paste production units) and cold storage systems, which could have preserved the excess for off-season use (Ayoade & Adeola, 2018). Farmers are then forced to sell at a loss or watch their produce rot, a reality that

affects income, reduces motivation, and hinders investment in agriculture.

The role of processing and storage facilities in mitigating these issues cannot be overstated. Processing adds value to raw produce, extends shelf life, improves packaging, and increases the marketability of goods. Storage, particularly when modern techniques are used, helps to stabilize supply, reduce losses, and make food available year-round. Technologies such as hermetic storage bags, metal silos, solar dryers, evaporative coolers, and cold rooms have been introduced in some parts of Nigeria with notable success (World Bank, 2020). These solutions are often more efficient, hygienic, and cost-effective in the long run than traditional methods.

However, the adoption of modern processing and storage technologies in Benin City remains low. Several factors are at play, high initial costs, lack of technical expertise, poor rural infrastructure, low awareness among farmers, and insufficient government support (Oluwatayo & Adedeji, 2019). Most smallholder farmers still rely on rudimentary methods like sun drying on bare ground, storing grains in jute bags or mud silos, and using wood-fired ovens for processing. While these methods may be low-cost, they are also prone to contamination, pest infestation, and spoilage, which significantly reduce product quality.

Compounding the issue is the poor state of rural roads and inconsistent power supply. Storage facilities, especially those requiring temperature control, depend on a reliable energy source. In Benin City and many parts of southern Nigeria, frequent power outages make it difficult to run cold storage units or mechanized processors efficiently (Nwankwo et al., 2018). This infrastructure gap discourages private investment and limits the functionality of even the few available modern facilities.

Climate change further aggravates the situation. Rising temperatures and unpredictable rainfall patterns impact both the timing of harvest and the storage environment. For example, excess humidity increases the risk of fungal growth in stored grains, while sudden heat waves can spoil perishable produce stored in poorly ventilated warehouses (IPCC, 2021). Without adaptive processing and storage solutions, farmers are left at the mercy of environmental shocks.

Internationally, countries like Kenya and India have made significant strides in addressing in

similar issues. In Kenya, the introduction of affordable solar-powered cold rooms through public-private partnerships has helped reduce post-harvest losses in fruits and vegetables by over 30% (Kigathi et al., 2022). In India, the government's support for rural food processing clusters and village-level storage has created jobs, increased farmer income, and stabilized food supply chains (Patel & Sharma, 2020). These global examples highlight the transformative potential of targeted investment in processing and storage, a lesson Nigeria can learn from.

Therefore, this study is both timely and necessary. By evaluating the existing processing and storage facilities in Benin City, identifying their strengths and weaknesses, and exploring the underlying barriers to access and adoption, the research aims to uncover actionable insights. The goal is not just to point out what's missing but to propose practical, scalable, and context-specific solutions that can improve the resilience and productivity of the agricultural sector in Benin.

In summary, agricultural processing and storage are critical pillars of a sustainable food system, especially in a city like Benin where agriculture is both a livelihood and a lifeline. Tackling the inefficiencies in these areas is key to reducing waste, improving farmer welfare, and ensuring that food remains available, affordable, and safe for all.

1.2 Statement of the Problem

Despite being a hub for agricultural activities in southern Nigeria, Benin City still struggles with one of the most persistent problems in food systems: post-harvest losses caused by inadequate processing and storage facilities (FAO, 2019; Adeoye et al., 2009). The issue here is not just the existence of these problems, it is the fact that they have been allowed to continue even in the face of new technologies and available knowledge (Oladele, 2012).

Many farmers still rely on age-old practices that have proven to be inefficient. Grains are sun-dried on bare earth, exposing them to dust, rodents, and moisture (Akinbile, 2007). Tubers are stacked in barns with little or no protection from heat and pests. Perishable items like vegetables, fruits, and dairy often spoil within days due to a lack of cold storage or proper packaging (Oluwatayo & Adedeji, 2019). In this kind of environment, even bumper harvests can turn into financial disasters.

Some modern facilities do exist; silos, cold rooms, improved dryers, but they are few and far

between. They are often concentrated in government projects or operated by larger agribusinesses, making them inaccessible to the majority of local farmers (Nwankwo et al., 2018). Where available, infrastructure bottlenecks like erratic power supply, poor maintenance culture, and lack of skilled personnel make these facilities ineffective (Eze & Ibekwe, 2007).

Additionally, financial barriers play a major role. Farmers and small agro-processors often cannot afford the capital investment needed to access or operate modern equipment. This is worsened by limited access to credit and government support (FAO, 2021). In many cases, they simply - make do with what they have, accepting high levels of loss as a normal part of farming life.

Knowledge gaps are another concern. Many farmers are not even aware of available alternatives or do not have the training to adopt better practices. Extension services, those that are supposed to educate and guide farmers, are either underfunded or non-functional in many communities (Oladele, 2012; Adebayo & Adedoyin, 2005). As a result, innovations that could reduce waste and increase profits remain underutilized.

The implications are far-reaching. Food that could help fight hunger is wasted. Prices fluctuate unnecessarily. Opportunities for local agro-industrial growth are missed. Most importantly, it becomes hard for agriculture to live up to its promise of driving sustainable development and food security in the region (FAO, 2020; World Bank, 2021).

This study was born out of the urgent need to confront these problems head-on, not by just listing them, but by evaluating the real state of processing and storage in Benin City, understanding the causes of inefficiencies, and identifying practical, scalable solutions that can empower both farmers and stakeholders across the agricultural value chain.

1.3 Objectives of the Study

1.3.1 Main Objective/Aim of Study

To assess processing and storage facilities in Benin City.

1.3.2 Specific Objectives

- To determine the challenges in processing and storage in Benin City.

- To determine information, age, academic qualifications, sex, and location.
- To determine the drying and storage methods (traditional or mechanized) being practiced in Benin City.
- To determine the predominant products or crops being processed in Benin City.

1.4 Research Questions

- What are the major challenges faced by farmers in processing and storing their products?
- How do inadequate storage facilities impact the quality and market value of agricultural products?
- What improvements can be made to enhance agricultural processing and storage in the region?
- What cost-effective storage and processing solutions can be adopted by small-scale farmers?
- How does the lack of adequate storage impact food prices and supply chains in the region?
- What level of awareness do farmers have regarding modern storage and processing techniques, and what are the barriers to adoption?
- How can local materials and indigenous knowledge be incorporated into developing more sustainable storage solutions?

1.5 Significance of the Study

Beyond economic benefits, improved storage and processing facilities can lead to higher quality agricultural products, reducing spoilage and contamination. This is particularly significant in the preservation of perishable crops, where inadequate post-harvest handling often results in substantial losses. Enhancing these facilities ensures that food reaches consumers in optimal condition, thereby reducing waste and promoting sustainability in agricultural production (Oladele, 2012).

Moreover, this research will be instrumental for policymakers, agricultural extension officers, and investors looking to develop sustainable agribusiness models in the region. It

supports the implementation of advanced preservation techniques such as hermetic storage, cold chain logistics, and controlled atmospheric storage, which can drastically improve the shelf life and marketability of produce. Additionally, modern processing methods like extrusion technology, hydrothermal treatment, and mechanized milling could transform raw agricultural outputs into higher-value products, increasing profitability for farmers.

From engineering students and professionals, this study could inspire community-driven innovation in agricultural tech, contributing to Nigeria's broader agenda for food security and job creation (Nwankwo et al., 2018).

Ultimately, this study contributes to academic discourse by expanding the knowledge base on agricultural engineering within the context of developing economies. The findings of this research will serve as a foundation for future studies in agricultural engineering, particularly in designing cost-effective, scalable, and environmentally sustainable post-harvest infrastructure. By integrating modern engineering solutions with traditional storage practices, this study aims to bridge the gap between technological advancements and local agricultural needs, fostering a more resilient and efficient food system.

1.6 Scope of the Study

This study focuses specifically on the processing and storage of agricultural produce within Benin City and its surrounding communities. In line with the study's objectives, the research will assess the types of processing and storage methods (traditional or mechanized) currently in use, with a strong focus on their efficiency, accessibility, and sustainability. Special attention will be given to identifying the challenges farmers face, their demographic characteristics (age, education level, gender, etc.), and the predominant crops processed in the region.

The scope also includes evaluating both individual and communal facilities, such as those managed by cooperatives, private firms, or government bodies, to understand their functionality and relevance to local farming systems. This will help determine the actual gaps between what is available and what is needed for efficient post-harvest handling.

Key products like grains, vegetables, cassava, yams, and other major food crops commonly cultivated in the region will be used as case examples for the study. These represent the bulk of food-related activities and thus offer a clear picture of how well processing and storage are

handled from harvest to market.

The study will not focus on large-scale commercial export-oriented agribusinesses or international trade systems, except where they directly intersect with local post-harvest handling. It will also exclude advanced topics like biotechnology processing or large factory-scale operations that are not within reach of the average local farmer.

The geographic focus is Benin City, but the findings may be useful for similar communities in Nigeria and West Africa facing comparable challenges.

1.7 Limitations of the Study

Like many field-based studies, this research comes with a few limitations that may influence the depth and reach of the findings.

Firstly, there are time and financial constraints. Conducting a thorough audit of all available processing and storage facilities in Benin City requires extensive travel, data collection, stakeholder engagement, and in some cases, technical evaluation, all of which are resource-intensive. Given the limited timeframe and budget, the research may only cover a representative sample rather than every existing facility.

Secondly, while the study seeks to capture a broad view of the processing and storage ecosystem, certain external factors like government policy shifts, sudden market changes, or unpredictable weather conditions may affect the accuracy of data during the study period. These dynamics are difficult to control and may not be fully accounted for in the research.

Thirdly, there are technological limitations. Some of the modern equipment or techniques mentioned may not be readily observable in the field due to their limited presence or operational downtimes. As a result, the study may rely on secondary data or reported usage rather than direct observation for certain technologies.

Finally, because agricultural technologies are constantly evolving, some of the findings or solutions proposed in this study may become outdated as new innovations emerge. However, the insights offered will still serve as a solid foundation for future research and strategic interventions aimed at improving post-harvest systems in similar settings.

CHAPTER TWO

LITERATURE REVIEW

2.1 What is Processing?

Processing refers to all post-harvest operations that transform raw farm products into forms that are more useful, marketable, and storable (Prof. J.C. Adama, 2023). These activities add value by improving appearance, taste, shelf life, and usability. Agricultural processing plays a crucial role in improving food security, reducing waste, and supporting rural development.

Agricultural processing can be grouped into:

- **Primary processing:** Basic operations such as cleaning, grading, sorting, and drying.
- **Secondary processing:** More advanced operations like milling, juicing, fermenting, or grinding (e.g., cassava to garri).
- **Tertiary processing:** Involves producing finished goods ready for consumption (e.g., packaged snacks, canned vegetables).

While Prof. Adama (2023) emphasizes the role of processing in shelf stability, FAO (2023) notes that lack of access to mechanized equipment remains a barrier in rural Nigeria. This contrast highlights the need to investigate equipment availability in Benin City.

2.2 Unit Operations in Processing

Unit operations are the building blocks of processing and refer to specific physical or chemical steps involved in transforming agricultural products. Each unit operation contributes to altering the product's form, increasing safety, and extending shelf life. Below are several unit operations used in agricultural processing:



Figure 2.1: Agro-processing sector (Source: Wixstatic, 2024)

2.2.1 Blanching

Blanching involves briefly boiling or steaming vegetables and then quickly cooling them in ice water. This stops enzymatic activity that causes spoilage, softens texture, and prepares food for freezing or drying. It also preserves nutrients, color, and flavor (Han, 2023).





Figure 2.2 – 2.5: Illustration of the blanching process step by step: from immersing vegetables in hot water, to rapid cooling in ice water. This demonstrates how heat inactivation stops enzymatic activity, which helps maintain food color, texture, and quality before storage or further processing. It visually reinforces the role of blanching as a preparatory step in post-harvest preservation. (Source: The Spruce Eats, 2024)

2.2.2 Drying

Drying removes moisture to prevent microbial growth and extend shelf life. It is one of the oldest preservation methods and is still widely used. Common drying methods include:

- **Open sun drying:** Exposing crops like maize or pepper to direct sunlight.



Figure 2.6: Open sun drying of pepper (Source: ResearchGate, 2023)

- **Solar drying:** Using enclosed structures like parabolic solar dryers to trap heat.



Figure 2.7: Solar Dryer (NSPRI, Ilorin)

- **Convective (mechanized) drying:** Using artificial heat sources such as kerosene or electric-powered dryers.



Figure 2.8: Mechanized drying of cassava using Flash Dryers (Source: <https://th.bing.com/th/id/OIP.J6BI9Sah11F980gwJjC23wAAAA?rs=1> HYPERLINK)

- **Cabinet dryers (NSPRI, 2023):** Enclosed dryers that allow control over temperature and airflow for faster, hygienic drying.



Figure 2.9: Cabinet Dryer. Source: Google.com

2.2.3 Size Reduction

Size reduction is the process of decreasing the particle size of agricultural produce into smaller, more manageable units using mechanical means such as milling, grinding, chopping, slicing, or crushing. It plays a vital role in postharvest processing by increasing the surface area of the material, which in turn improves the efficiency of subsequent operations like drying, mixing, and cooking. Size reduction also helps in achieving uniformity, improving the texture of food products, and making transportation and packaging easier. It is especially important in producing flour from grains, crushing oil seeds, or slicing tubers for drying or frying. (Fellows, P. J. (2009). *Food Processing Technology: Principles and Practice* (3rd ed.). Woodhead Publishing).

- **Grinding:** Grinding reduces large particles into finer forms to make them easier to use or consume. This operation is commonly used in cereals (e.g., maize to flour), spices (e.g., ginger to powder), and animal feeds.
- **Milling:** Milling is similar to grinding but often refers to removing the outer layer (like bran or husk) and reducing particle size, especially in cereals like rice or wheat. It's used to enhance shelf life and improve product quality.

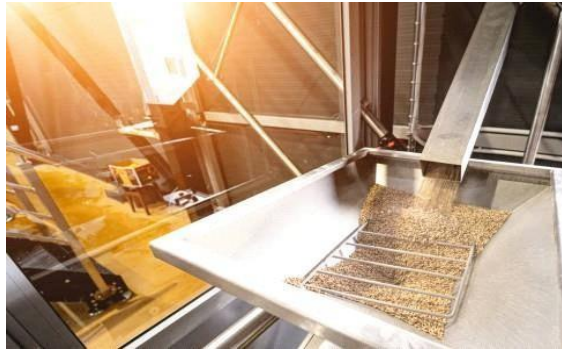


Figure 2.10: Industrial grain milling setup converting whole grains into refined flour. Milling removes bran and germ, producing shelf-stable products. Source: (iStock 2024)

- **Crushing:** Crushing involves applying force to break down bulky agricultural materials, especially oilseeds like groundnuts or palm kernels, to extract oil. It's also used for sugarcane and fruits to release juice or pulp.
- **Chopping:** Chopping refers to cutting produce into coarse, uniform pieces. This is common with vegetables or tubers like cassava and yam, often before drying or frying. It ensures even cooking and easier storage.
- **Slicing:** Slicing produces thin, flat sections of food items like potatoes, plantain, or carrots. Sliced products dry faster and more evenly, and this process is important in chips production or drying for storage.

These operations improve processing efficiency, uniform cooking/drying, packaging, and product appearance (Fellows, 2009; Oluwole et al., 2013).

2.2.4 Winnowing

Winnowing is a traditional and mechanical unit operation used to separate lighter, unwanted materials such as chaff, husks, dust, and other debris from heavier grains like rice, millet, maize, and wheat. This process is typically done after threshing and is essential in improving the quality and cleanliness of harvested grains.

In its traditional form, winnowing involves tossing the grains into the air so that the wind blows away the lighter particles while the heavier grains fall back down. In modern settings, winnowing machines or air classifiers are used to automate this process by blowing controlled air through the grains, allowing for more efficient and large-scale separation.

This operation plays a significant role in reducing post-harvest losses, maintaining the quality of produce, and preparing grains for safe storage or further processing (FAO 2023).



Figure 2.11: Traditional winnowing process using a flat basket to separate grain from chaff by wind action (source: Careers360 2024) <https://school.careers360.com/chemistry/winnowing-topic-pge>).

2.2.5 Pasteurization and Sterilization

Pasteurization and sterilization are heat-based unit operations used mainly in liquid food processing to extend shelf life and ensure food safety.

Pasteurization involves heating food (like milk or juice) to a specific temperature (usually between 60–85°C) for a short time to kill most pathogenic microorganisms without significantly affecting the food's taste or nutritional value. It is commonly used in dairy processing, fruit juice preservation, and egg products.

Sterilization, on the other hand, uses higher temperatures (above 100°C) and longer heating times to destroy all forms of microorganisms, including spores. This is often used for canned foods and baby formula to make the food shelf-stable for months or even years.

Both operations are vital in ensuring public health, extending product shelf life, and minimizing food spoilage.

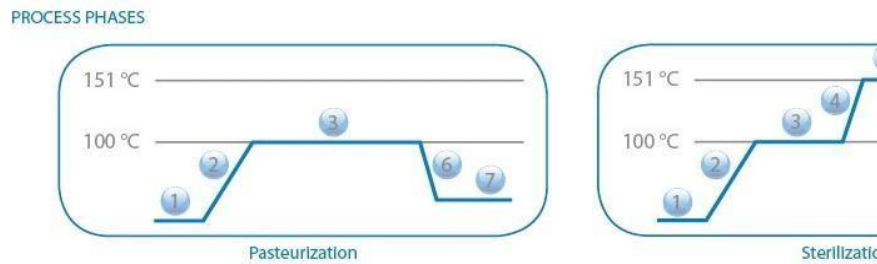


Figure 2.12: *Pasteurization vs sterilization process (Sources: Wikimedia Commons & ScienceDirect, 2024).*

2.2.6 Dehulling / Decortication

Dehulling (also called decortication) is a mechanical unit operation that removes the hard outer covering (hull or husk) from seeds, legumes, and grains. This is a key step in the processing of crops like soybeans, millet, groundnut, and rice.

The hull is inedible and often contains anti-nutritional factors, so its removal improves the digestibility and palatability of the grain. Dehulling also enhances the milling performance and reduces cooking time. In modern systems, this is done using dehulling machines equipped with rollers, blades, or abrasion surfaces.

Dehulling not only improves food quality but also helps in reducing bulk and increasing the market value of agricultural products (Food and Agriculture Organization [FAO], 2019).

Other Unit Operations Include:

- **Cleaning:** Removal of soil, stones, or debris from produce. Often the first step after harvesting.
- **Sorting and Grading:** Classification by size, ripeness, or quality. Important for market value.
- **Peeling:** Removing outer layers of roots and tubers (e.g., yam, cassava).
- **Fermentation:** Conversion of carbohydrates to alcohol or acids using microorganisms (e.g., cassava for garri or starch).
- **Juicing:** Extracting liquid content from fruits such as oranges or pineapples. (NSPRI, 2023)
- **Packaging:** Wrapping or enclosing processed items to protect against contamination.
- **Sieving:** Refining powdered items to ensure uniform texture (e.g., flour, starch).

- **Crystallization:** It is the process where a solid forms from a liquid or gas in a structured, organized way, like sugar or salt forming crystals from a solution. This helps in purifying products and creating desired textures or shelf stability. For example, sugar refining uses crystallization to get pure sugar crystals.
- **Clarification:** This is about removing solids or impurities from liquids to make them clear, like filtering juice or oil. It improves the quality, appearance, and sometimes the safety of the product (Food and Agriculture Organization [FAO], 2019).

These operations may vary depending on the type of product and available technology. Mechanized methods are more efficient but require financial investment and technical knowledge.

2.3 Problems of Processing

- **Limited access to modern equipment:** Many smallholder farmers and processors lack availability of up-to-date machinery, which slows down production and limits the quality and quantity of processed goods (Adejumo & Raji, 2020).
- **High cost of machinery:** The price tag on advanced processing machines is often too steep for local farmers and small businesses, making it difficult for them to invest in tools that could boost efficiency and output.
- **Inconsistent power supply:** Frequent power outages in Benin City disrupt the operation of electric processing equipment, causing delays and increasing the risk of spoilage during production.
- **Lack of technical knowledge:** Many processors lack formal training or access to technical support, which affects their ability to properly operate machines or adopt best practices.
- **Cultural resistance to new methods:** Traditional methods are deeply rooted in the community, and some farmers or processors hesitate to adopt unfamiliar technologies or techniques, even when they offer clear benefits (Adejumo & Raji, 2020).

2.4 Benefits of Processing

- **Extends shelf life:** Proper processing techniques, such as drying, blanching, and packaging, slow down spoilage and decay, allowing agricultural products to stay fresh

longer (Prof. J.C. Adama, 2023).

- **Increases market value:** Processed products generally fetch higher prices in the market because they are easier to store, transport, and sell compared to raw produce.
- **Reduces post-harvest losses:** Processing minimizes waste by stabilizing perishable items, which is especially important in regions where storage infrastructure is weak.
- **Enhances food safety:** Many processing steps remove or reduce harmful pathogens and contaminants, making food safer for consumers.
- **Improves food availability during off-seasons:** Processing allows surplus produce harvested in peak seasons to be preserved and consumed when fresh supplies are scarce (Prof. J.C. Adama, 2023).

2.5 What is Storage?

Storage refers to the process of safely keeping harvested or processed agricultural products in an environment that preserves their quality until they are ready to be consumed or sold.

Proper storage helps prevent damage caused by pests, microbial growth, moisture, and spoilage, which are common issues that lead to significant post-harvest losses. Effective storage is essential for maintaining food safety, extending shelf life, and stabilizing market supply, especially in places where fresh produce is not available year-round (FAO, 2019).

2.6 Types of Storage

- **Traditional Storage:** Traditional processing and storage methods have been in use for centuries and are still prevalent in many rural areas. While they may lack efficiency compared to modern systems, they remain essential due to their affordability and accessibility (FAO, 2021).
- **Modern Storage:** Modern agricultural processing and storage facilities leverage advanced technology to enhance efficiency, reduce losses, and ensure food safety. Silos, cold rooms, hermetic bags, evaporative coolers (NSPRI, 2023).



Figure 2.13: Traditional Vs. Modern Storage - Source: Pexels.com

2.7 Facilities in Storage

Various types of storage facilities are used to preserve agricultural products, depending on the type of produce and the available technology. Some common storage facilities include:

- **Cribs and barns:** Traditional structures primarily used for drying and storing grains, offering basic protection from pests and weather.
- **Improved yam barns:** Specifically designed to store tubers like yams, these barns provide better ventilation and protection from heat and pests compared to traditional methods.



Figure 2.14: Yam Barn with Wire Mesh source: (NSPRI Ilorin)

- **Galvanized silos:** Metal storage containers that offer secure, moisture-resistant environments ideal for storing grains on a larger scale.



Figure 2.15: A galvanized steel silo used for large-scale grain storage. The structure provides a controlled, moisture-resistant environment that protects grains from pests and spoilage.

(Source: Savona Equipment, n.d.)

- **Hermetic steel drums:** Airtight containers that limit oxygen, preventing pest infestation and spoilage in stored grains and legumes.
- **Refrigerated units:** Used for highly perishable products like fruits, vegetables, and dairy, these units control temperature and humidity to extend shelf life.
- **Pot-in-pot evaporative coolers:** Low-cost, eco-friendly cooling devices that use evaporation to reduce temperature, suitable for small-scale farmers storing fruits and vegetables (Ndukwu, 2014).



Figure 2.16: Pot-in-Pot Cooler (Source: <https://www.semanticscholar.org/paper/A-heat-and-mass-transport-model-of-clay-pot-coolers-Rehman-McGarrigle/e0b0a4b433935961ed65119785131849682c48>)

2.8 Problems of Storage

Storage faces several challenges that limit its effectiveness. Pest infestation and microbial spoilage cause significant losses if products aren't properly protected. High humidity and poor ventilation create conditions that speed up decay. Many farmers also lack the training or awareness to manage storage correctly, and inadequate infrastructure makes it hard to maintain good storage environments (FAO, 2023).

- **Pest infestation:** Insects, rodents, and other pests can damage stored crops, causing significant losses and contamination.
- **Microbial spoilage:** Bacteria, molds, and fungi thrive in improper storage conditions, leading to food decay and health risks.
- **High humidity:** Excess moisture encourages mold growth and speeds up spoilage, reducing the shelf life of produce.
- **Poor ventilation:** Lack of air circulation traps heat and moisture, creating an environment where spoilage and pests can flourish.
- **Lack of training or awareness:** Farmers and handlers who are not properly educated on best practices may mishandle produce, increasing losses.
- **Inadequate infrastructure:** Poor storage facilities and equipment limit the ability to protect crops from damage, pests, and spoilage.

2.8 Benefits of Storage

Storage offers several key advantages that are vital for farmers and the food system. It reduces post-harvest losses by keeping crops safe from pests and spoilage. Maintaining nutritional quality ensures the food stays healthy and safe for consumption. A steady food supply throughout the year helps stabilize prices and availability. Better storage also enhances farmer income by allowing bulk marketing and timing sales for better returns. Ultimately, effective storage promotes food security by minimizing waste and improving access to food (Prof. J.C. Adama, 2023).

- **Reduces post-harvest losses:** Proper processing and storage techniques help minimize food spoilage and damage after harvest, ensuring more produce reaches consumers.
- **Maintains nutritional quality:** These methods preserve the essential nutrients in food, keeping it healthy and safe to eat over time.
- **Ensures steady food supply:** By storing food properly, supply can be extended beyond harvest seasons, providing consistent availability throughout the year.
- **Enhances farmer income:** Reduced losses and the ability to sell in bulk or off-season enable farmers to increase their earnings.
- **Enables bulk marketing:** Effective storage allows farmers to accumulate larger quantities of produce, attracting bigger buyers and better market prices.
- **Promotes food security:** Overall, these benefits contribute to a more reliable supply of nutritious food, helping to reduce hunger and improve community health.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of Project Area (Benin City)

This study was conducted in Benin City, the capital of Edo State, located in southern Nigeria. The city is a hub for agricultural activities including the cultivation and post-harvest handling of crops such as cassava, maize, and vegetables. The research focused on three Local Government Areas (LGAs): Oredo, Egor, and Ovia North-East, selected for their diverse agricultural profiles and relevance to post-harvest processing and storage.

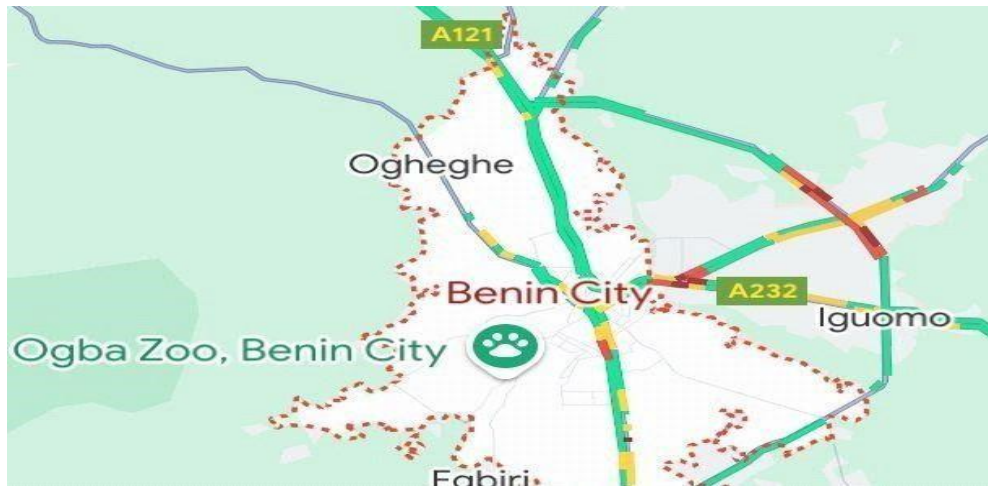


Figure 3.1: Map of Benin City, Edo State, Nigeria, showing key agricultural zones – Source: Google Maps, 2024. Benin City, Edo State, Nigeria – Agricultural zones. (Retrieved from <http://www.google.com/maps>)

3.2 Field Survey

To gather firsthand data on agricultural processing and storage practices, a field survey was employed as the primary method of data collection. Field surveys are commonly used in agricultural research to obtain accurate and location-specific information directly from stakeholders such as farmers, processors, and storage facility operators (Aina, 2002; Oseni & Winters, 2009). This approach was suitable for understanding practical challenges and evaluating existing processing and storage facilities within the study area.

3.3 Development of the Questionnaire

In order to collect relevant data for this research, a structured questionnaire was developed and used as the main data collection instrument. The questionnaire was designed to obtain detailed information on the current state of agricultural processing and storage systems in Benin City, focusing on the crops processed/stored, types of facilities and equipment used, level of technology adoption (traditional or mechanized), and the challenges encountered by stakeholders in the field.

The questionnaire was divided into two main parts:

- Part I: Processing Systems
- Part II: Storage Systems Each part contained three sections:
 - **Section A: Background Information:** Demographic data (age, gender, education, household size, location)
 - **Section B: Processing/Storage Practices:** Crop types, end products, equipment, scale of operation, technology type
 - **Section C: Challenges Faced:** Issues such as funding, infrastructure, technical knowledge, pest control

Both closed and open-ended questions were included to enable quantitative analysis and qualitative insights.

Administration of the Questionnaire

The questionnaire was administered on the respondents by the author. A rapid urban approach was adopted; respondents were selected at random from different areas of Benin City and interviewed in their homes, farms, and sales points.

The areas covered included communities such as Efehi, Okhuoromi, Uselu Market, Adolor, and Eguavoen, as well as other wards within Oredo, Egor, and Ovia North-East LGAs. In the process of administering the questionnaire, I took note of processing and storage facilities in the study area. Apart from these areas covered by the use of the questionnaire, a tour of other parts of the city was undertaken to observe and record the processing and storage facilities.

3.4 Touring of the Project Area

A physical tour of the project area in Benin City was undertaken to observe the existing agricultural processing and storage facilities, infrastructure, and environmental conditions. This hands-on approach was essential to gain a deeper contextual understanding beyond what could be captured through questionnaires and interviews. Observations during the tour provided valuable insights into practical challenges such as facility conditions, equipment usage, and local environmental factors that affect post-harvest handling and storage.

This qualitative approach complemented the quantitative data collected and helped to triangulate findings, ensuring a more holistic understanding of the agricultural practices in the area. Field visits have been shown to enrich data quality by providing direct exposure to the research environment and allowing researchers to capture nuances that might otherwise be missed.

3.5 Locations Visited

The study covered three LGAs and one research institute:

- **Oredo LGA:** Urban wards such as GRA, Etete, Iyaro, and New Benin were visited. Observations included cold storage units and smoked fish processing facilities.
- **Egor LGA:** Semi-urban areas like Uwelu, Ugbowo, and Uselu Market were surveyed. Traditional preservation methods such as water sprinkling and bag stacking were noted.
- **Ovia North-East LGA:** Rural communities including Okada, Ekiadolor, and Oluku were visited. Cassava processing and small-scale mechanized techniques were observed.
- **NIFOR (Nigerian Institute for Oil Palm Research):** A visit was made to assess modern processing and storage technologies used in oil palm production.

Each location was selected to represent a distinct segment of the agricultural value chain, ranging from household-level practices to institutional-scale operations.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Background of Respondents

This section presents the demographic characteristics of respondents across the three LGAs.

4.1.1 Age Distribution of Respondents

The demographic profile of respondents' sheds light on the human element behind agricultural processing and storage in Benin City. Understanding their age, education, household size, and gender distribution helps explain both the opportunities and constraints observed in their practices.

4.1.2 Age Distribution

Respondents' ages ranged from 25 to 50 years. The majority were within the 25–35 years bracket, followed by 36–45 years, with fewer participants above 45. This finding is consistent with the youth-driven nature of small-scale agriculture in Nigeria, where younger adults dominate physically demanding activities such as farming, peeling, and smoking.

This age pattern suggests two important dynamics, which are:

- **Agricultural continuity:** Younger workers ensure the sustainability of the sector, preventing agriculture from being left solely to aging rural populations.
- **Limitations of youth involvement:** While energetic, younger respondents also cited financial barriers and lack of technical training, indicating that enthusiasm alone cannot overcome structural challenges.

Table 4.1 Age Distribution of Respondents

Age Range (Years)	Frequency	Percentage (%)
25–35	25	37.3
36–45	20	29.9
46–50	15	22.4
Above 50	7	10.4
Total	67	100

4.1.3 Educational Qualification of Respondents

The respondents' educational qualifications varied widely, from no formal education to university degrees. A significant proportion were SSCE holders, with a few attaining higher educations. This uneven distribution reflects the dual nature of agriculture in Benin City: it attracts both semi-educated small-scale farmers and formally educated individuals who enter the sector through processing enterprises or institutional roles (such as those at NIFOR).

Educational levels influence processing outcomes directly. Respondents with formal education, such as those at NIFOR or the cassava processor with a B.Sc., were more likely to adopt mechanized equipment and understand maintenance requirements. On the other hand, respondents with no formal education primarily relied on traditional, labor-intensive methods. This finding agrees with Oluwatayo & Adedeji (2019), who emphasized the link between farmer education and technology adoption.

Table 4.2: Educational Qualification of Respondents

Educational Level	Frequency	Percentage (%)
No Formal Education	10	14.9
JSSCE	12	17.9
SSCE	20	29.9
B.Sc./HND	18	26.8
OND	4	6.0
NCE	3	4.5
Total	67	100

4.1.4 Household Size of Respondents

Table 4.3: Household Size Distribution of Respondents Household Size Frequency Percentage (%)

1-2	8	11.9
3-5	42	62.7
Above 5	17	25.4
Total	67	100

Most respondents reported small to medium household sizes (3–5 members), which formed the largest group (62.7%). Unlike rural communities where large households supply unpaid farm labor, respondents in this study mostly ran commercial-oriented operations, relying more on hired or cooperative labor. This shows a gradual shift from traditional subsistence farming to more market-driven processing and storage activities in urban and peri-urban Benin City.

4.1.5 Gender Distribution of Respondents

Table 4.4: Gender Distribution of Respondents

Gender	Frequency	Percentage (%)
Male	40	59.7
Female	27	40.3
Total	67	100

The gender profile revealed an even split between male and female respondents. Women dominated activities such as fish smoking and tomato vending, while men were more engaged in mechanized cassava processing and large-scale fruit cultivation. This distribution reflects broader Nigerian agricultural gender roles, where women are highly visible in food vending and small-scale processing, while men are more associated with activities requiring capital investment or heavy machinery.

The background characteristics reveal a sector shaped by youth, semi-educated workers, and balanced gender participation. Yet, the contrast between small-scale operators and institutional actors like NIFOR is stark: while local farmers struggle with minimal education, few workers, and limited facilities, NIFOR employs 30 formally trained staff and advanced machinery. This contrast underscores the inequalities in access to resources, even within the same city.

4.2 Processing Type and Level

The survey revealed a diverse range of processing activities across Oredo, Egor, Ovia North-East, and NIFOR. These activities can be grouped into three main levels:

1. Traditional (manual, low-cost, small scale)
2. Semi-mechanized (manual + local machines)
3. Modern institutional-scale (fully mechanized)

4.3 Traditional Processing Practices

Traditional processing practices were widespread in the study area, particularly in smallholder and household-level operations. They rely heavily on manual labor, locally available tools, and low-cost inputs. Examples observed include:

4.3.1 Smoked Fish Production (Okhuoromi, Oredo LGA):

- Fish were cleaned, gutted, seasoned, and smoked using firewood-powered kilns.
- The kilns are typically constructed from mud or bricks, with wire racks placed over open fire chambers.
- While effective for preservation, the method is labor-intensive and exposes both workers and consumers to health risks due to smoke and uneven heating.



Figure 4.1: Smoked dried fish arranged on racks during the traditional preservation process



Figure 4.2: Fresh catfish harvested for processing and distribution in Benin City.

4.3.2 Pepper and Tomato Handling (Uselu Market, Egor LGA):

- Vendors relied on basic preservation methods such as sprinkling water on unsold produce to maintain firmness.
- Produce was stored under shaded stalls or ventilated areas to reduce sun exposure.
- Spoiled items were removed daily, highlighting the fragility of perishable crops without advanced preservation facilities.



Figure 4.3 – 4.7: Display of fresh tomatoes and peppers in open market stalls, showing how produce is arranged in heaps, baskets, and trays under shaded areas to attract buyers and maintain freshness.

4.3.3 Cassava Peeling (Eguavoen, Ovia North-East LGA):

- Manual peeling using knives remained the norm.
- While low-cost, manual peeling is slow, requires significant labor, and results in inconsistent outputs.



Figure 4-8: Grated cassava mash packed inside a woven sack for dewatering during garri processing



Figure 4.9: Peeled cassava tubers placed in a bowl, ready for washing and further processing.

4.3.4 Field Observations

- In **Okhuoromi**, fish processors still depend on firewood kilns, which, though effective, expose workers to smoke and health hazards.

- At **Uselu Market**, traders rely on simple methods like water sprinkling to preserve tomatoes and peppers, but spoilage remains high.
- In **Eguavoen**, manual cassava peeling slows production and reduces output quality.

4.3.5 Discussion

Traditional processing remains dominant because it's affordable, requires no technical training, and fits local resource levels. However, it comes with significant drawbacks, including:

1. High labour demand and low productivity
2. High spoilage risk due to lack of proper preservation
3. Health hazards (e.g., smoke from kilns)
4. Limited scalability

This finding supports FAO (2019), which reported that reliance on traditional processing methods in sub-Saharan Africa contributes to post-harvest losses exceeding 30% annually.

4.4 Semi-Mechanized Processing Practices

Semi-mechanization was evident in medium-scale enterprises, particularly in cassava processing. At Eguavoen (Ovia North-East), garri production combined manual and mechanized operations.

1. **Grinding:** Diesel-powered cassava graters were used to shred tubers into pulp.
2. **Pressing:** Hydraulic jacks compressed cassava mash to remove excess water.
3. **Roasting:** Garri was roasted in large iron pans over wood fires

This blend of manual and mechanical steps highlights how local processors adapt mechanization to improve efficiency without completely abandoning traditional methods.



Figure 4.10 – 4.12: Locally fabricated cassava grinding machines used in small-scale garri production across Benin City.



Figure 4.13: Garri flakes displayed in a bowl after processing, showing the final product ready for consumption or sale.

4.4.1 Discussion

Semi-mechanization reduces manual labour, improves efficiency, and allows moderate scaling up of production. However, the locally fabricated machines are often:

1. Prone to breakdowns due to poor maintenance
2. Expensive to operate because of fuel dependency
3. Limited in capacity compared to industrial machinery

These findings align with Adejumo & Raji (2020), who noted that mechanization in Nigerian agriculture is often fragmented and hampered by limited access to credit facilities and technical support.

4.5 Modern Institutional-Scale Processing (NIFOR)

The Nigerian Institute for Oil Palm Research (NIFOR) represents the highest level of processing sophistication encountered during the study. Unlike smallholder enterprises, NIFOR employs advanced, modern equipment, including:

1. **Clarifiers:** for separating oil from water and sludge.
2. **Sterilizers:** for steam-heating palm fruits, making oil extraction easier.
3. **Digester Screw Presses:** for efficiently crushing sterilized fruits to release oil.
4. **Full Bunch Strippers:** for detaching fruitlets from fresh fruit bunch



Figure 4.14: Clarifier used for separating palm oil from water and sludge during processing at NIFOR



Figure 4.15: Sterilizer for steam-heating palm fruits to ease oil extraction.



Figure 4.16: Digester screw press used to crush sterilized palm fruits and release oil.



Figure 4.17: Full bunch stripper designed to detach fruitlets from palm fruit bunches.



Figure 4.18: Palm fruits separated from the bunch, prepared for processing into palm oil.

Unlike household processors, NIFOR operates at a commercial scale, ensuring uniform quality, higher yields, and food safety compliance. The contrast between NIFOR and smallholder enterprises underscores the two-track system of agriculture in Nigeria:

1. A majority of small-scale farmers use traditional or semi-mechanized methods with limited output.
2. A minority of government-backed or private institutions employ modern technology, yielding higher productivity.

This imbalance perpetuates inequality in market competitiveness. While NIFOR thrives with modern machinery and government support, smallholders struggle with inefficiencies.

4.5.1 Discussion

The findings reveal that processing in Benin City is dominated by traditional methods, with semi-mechanized systems serving as a transitional stage. Only institutional actors like NIFOR operate at modern, industrial capacity. Barriers to wider mechanization include:

1. Financial constraints (limited access to loans).
2. Infrastructure challenges (unreliable power supply, poor roads).
3. Technical capacity gaps (low education levels among workers).

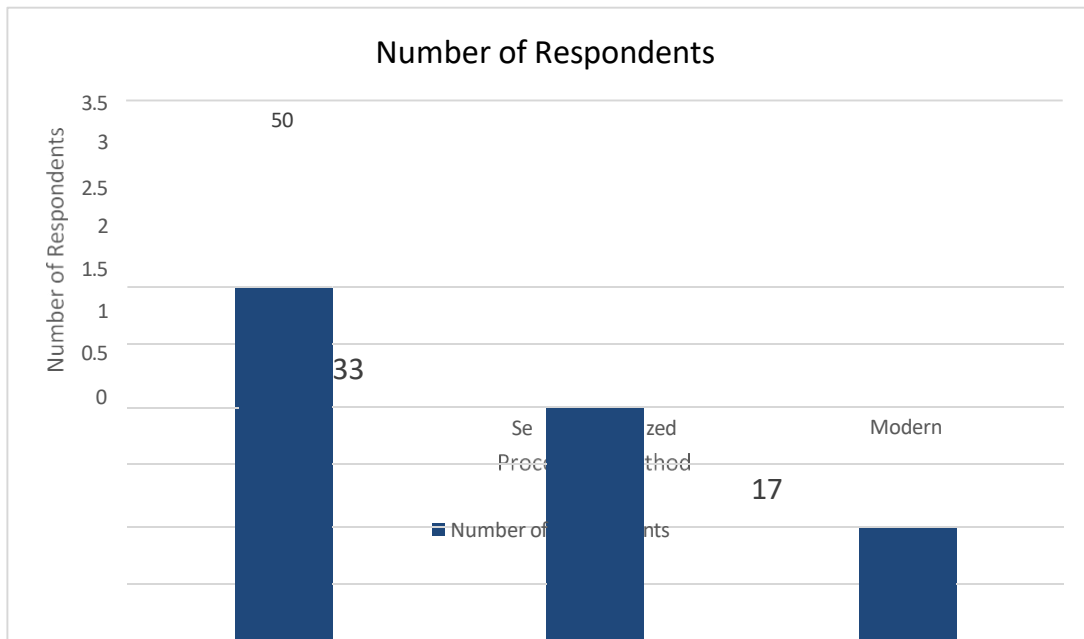


Figure 4.19: illustrates the distribution of respondents by processing method. Out of the 67 respondents interviewed, 34 (50.7%) relied primarily on traditional processing techniques such as fish smoking, tomato preservation, and cassava peeling. Twenty-two respondents (32.8%) reported the use of semi-mechanized systems, mainly in cassava garri production and cold storage. Only 11 respondents (16.4%) operated modern industrial-scale facilities, as observed at NIFOR.

4.6 End Products of Processing and Storage

The study identified a variety of raw materials and their corresponding end products. Table 4.5 summarizes these findings.

Table 4.5: Raw Materials and End Products

Raw Material	End Product
Cassava	Garri
Fresh Fish	Smoked Fish
Cucumber/Watermelon	Fresh fruits for sale
Pepper/Tomato	Fresh produce for sale

Raw Material	End Product
Groundnut	Dried groundnut kernels
Frozen Foods (meat, poultry, fish)	Preserved frozen foods
Palm Fruits (NIFOR)	Palm Oil

4.6.1 Cassava to Garri

Cassava processing was primarily geared towards producing garri, a staple food consumed widely in Nigeria. The process involved peeling, grinding, pressing, roasting, and sieving. Garri production ensures cassava is preserved for longer periods compared to raw tubers, which spoil quickly.



Figure 4.20: Finished packaged garri neatly stored in woven sacks for commercial distribution (Source: WeAfrique, 2023).

Garri adds value to cassava and stabilizes food supply. However, the small-scale nature of production means limited output. Farmers reported constraints such as limited land space and lack of mechanized peelers. These findings echo Oluwole et al. (2013), who identified manual peeling as the most time-consuming bottleneck in cassava processing.

4.6.2 Fresh Fish to Smoked Fish

Smoking fish extends shelf life, adds flavor, and makes transportation easier. Smoked fish is a high-demand product in Oredo, supplying markets within and outside Benin City.



*Figure 4.21: Smoked fish arranged on racks as part of the traditional preservation process
(Source: Dreamstime, 2023)*

While smoking adds value, the reliance on firewood increases production costs and exposes processors to health risks. Lack of modern kilns also results in inconsistent quality. The situation aligns with World Bank (2020), which highlighted inefficient fish smoking as a contributor to post-harvest losses in Nigeria’s fisheries.

4.6.3 Fresh Vegetables and Fruits

Cabbages, watermelons, garden eggs (Egg plants), peppers, and tomatoes were largely sold fresh. Minimal preservation methods (sprinkling water, shade storage) were employed.



Figure 4.22: Piles of fresh watermelons displayed at local market stalls, showing common methods of bulk sale and distribution in Benin City.



Figure 4.23: Garden eggs spread out on trays for retail display in a local market

The near absence of modern storage exposes these crops to rapid spoilage. Farmers reported losing 3 - 5% of cucumbers/watermelons during transit alone due to poor road conditions.

Tomatoes and peppers, being highly perishable, deteriorate quickly without cold storage. These findings are consistent with FAO (2021), which reported that perishable crops in Nigeria lose 30 - 50% of yield post-harvest.

4.6.4 Groundnut to Dried Kernels

Groundnuts were preserved by drying and storing in polypropylene bags placed on raised platforms. This traditional method prevents ground contact, reducing moisture and pest damage.





Figure 4.24 – 4.26: Groundnuts displayed in different forms: spread out for drying, contained in a sieve for cleaning, and stored in a sack for preservation and sale.

Although effective in the short term, long-term storage remains risky due to pest infestation and mould. Improved hermetic storage technologies (e.g., airtight steel drums) could reduce losses, but these were absent in Egor.

4.6.5 Frozen Foods in Cold Rooms

Commercial cold rooms in Oredo stored frozen poultry, fish, and meat at -18°C to -20°C . Products were neatly stacked on pallets to ensure ventilation and prevent cross-contamination. This is one of the few fully modern storage systems observed. However, frequent power outages threaten operations. Respondents noted that generator costs consume a large portion of revenue, reducing profitability.

4.6.6 Palm Fruits to Palm Oil (NIFOR)

At NIFOR, palm fruits were processed into palm oil using advanced machinery. Unlike other products, palm oil production was entirely mechanized, with minimal losses.



Figure 4.27: Freshly processed palm oil being poured into a bowl for cooling and packaging.



Palm oil production at NIFOR represents the most advanced form of value addition observed. Unlike smallholder enterprises, NIFOR faced no major storage issues since oil is kept in modern double storage tanks. This highlights the transformative effect of government-backed investments.

The findings show that most agricultural products in certain areas of Benin City are either sold fresh or converted into semi-processed staples (garri, smoked fish). Only NIFOR and cold room operators achieve industrial-scale preservation.

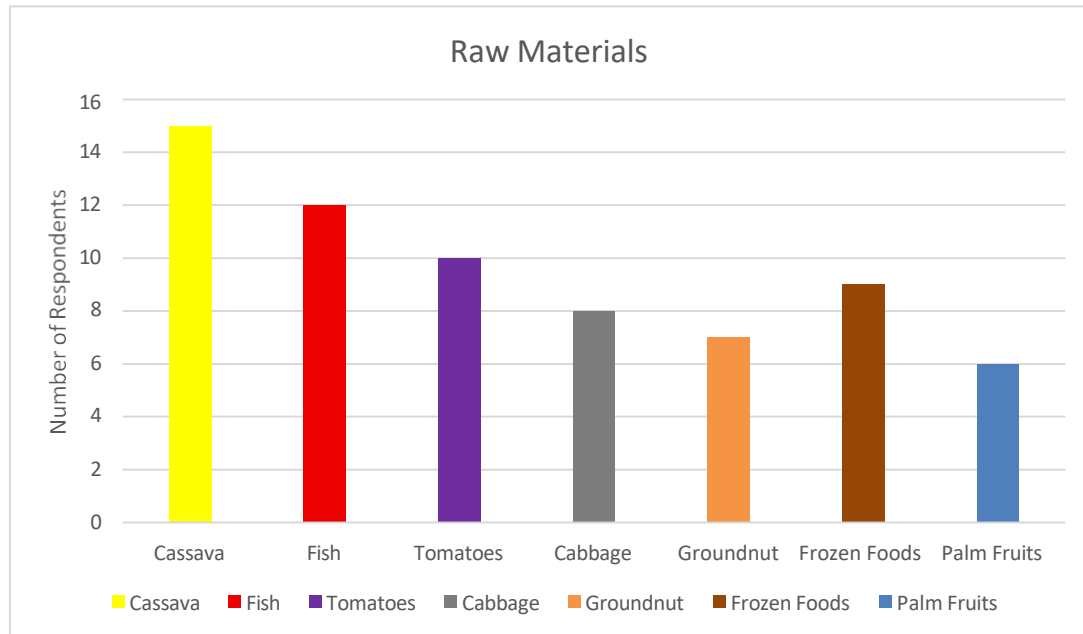


Figure 4.28: This reveals that cassava and fish accounted for the largest share of respondents' raw materials, reflecting their central role in Benin City's food economy. Tomatoes, cabbages, and groundnuts were also significant, though largely sold in fresh form with minimal preservation. Frozen foods and palm fruits were less represented but had more advanced preservation and processing. Overall, the chart emphasizes that the majority of outputs remain in semi- processed or raw forms, with very limited advanced value addition such as canning, juicing, or flour conversion. This limits profitability and contributes to post-harvest losses.

4.7 Facilities Involved in Processing and Storage

The study revealed that the majority of agricultural activities in Benin City rely on traditional and semi-mechanized facilities, with fully mechanized infrastructure being rare. Tables 4.6 and 4.7 summarize the range of facilities identified across different crops and localities.

Table 4.6: Processing Facilities

Crop/Product	Facilities Used	Mechanized, Traditional, or Modern
Cassava	Grinder, Hydraulic Press, Roasting Pot	Semi-Mechanized
Fish	Firewood Smoking Kiln	Traditional
Pepper/Tomato	Shade, Water Sprinkling	Traditional
Vegetables	Solar Dryer	Modern



Figure 4.29: Traditional smoking kiln used for fish processing in Benin City, showing firewood-based preservation methods

4.8 Storage Facilities

Table 4.7: Storage Facilities Identified in Benin City

Crop/Product	Facilities Used	Mechanized, Traditional, or Modern
Groundnut	Bags on Raised Wooden Platforms	Traditional

Watermelon	Ventilated Store, Soft Padding	Traditional
Frozen Foods	Cold Room with Compressor/Condenser	Mechanized
Cucumber/Watermelon	Bag padding, sprinkling water	Traditional
Grains	Silo	Modern

The data shows that traditional facilities dominate agricultural processing and storage in Benin City. For instance, groundnuts were kept in polypropylene bags placed on raised wooden platforms to reduce moisture absorption, while watermelons were stored in ventilated sheds with soft padding. Similarly, tomatoes and peppers were preserved with shade structures and light water sprinkling. These approaches are cost-effective but rudimentary, offering limited protection against spoilage.

Cassava processing was a notable example of semi-mechanized activity. Here, processors employed diesel-powered graters and hydraulic presses, reducing manual drudgery while still depending on traditional roasting methods using firewood. This hybrid system improved efficiency and product output but still lagged far behind modern industrial standards.

The few mechanized systems observed were in cold storage facilities and at NIFOR. Cold rooms were equipped with compressors, condensers, and temperature monitoring devices, enabling long-term preservation of frozen foods. At NIFOR, advanced facilities such as clarifiers, sterilizers, and digester screw presses represented the most modern infrastructure in the study, highlighting the contrast between small-scale operators and government-supported institutions. In addition, fieldwork revealed the presence of solar dryers and silos, which, though less widespread, are clear examples of modern innovations. The solar dryer provided hygienic and efficient preservation of vegetables compared to open-air drying, while silos offered large-scale, long-term grain storage that minimized pest infestation and moisture damage. Their inclusion underscores the gradual but uneven transition toward modern agricultural facilities in Benin City.



Figure 4.30: Interior of a cold room storage facility with frozen foods arranged on pallets to ensure proper ventilation and preservation.



Figure 4.31: Modern solar dryer facility observed during fieldwork, used for hygienic and efficient preservation of vegetables and fruits.



Figure 4.32: Modern solar dryer facility observed during fieldwork in Oredo LGA, used for hygienic and efficient preservation of vegetables and fruits.

Implications

- The dominance of traditional facilities reflects low capital investment and barriers to mechanization, consistent with Adejumo & Raji (2020) who emphasized that smallholder processors rarely access modern equipment due to financial limitations.
- Mechanized facilities, where available, significantly improved product quality and shelf life, particularly for frozen foods, palm oil and products preserved using solar dryers and silos. However, the high cost of installation, frequent maintenance needs, and unstable electricity supply limit wider adoption.
- The contrast between smallholder reliance on shade and firewood, versus NIFOR's modern technology and the selective adoption of advanced facilities like solar dryers and silos, mirrors the broader Nigerian agricultural landscape where progress is uneven and dependent on institutional support.

4.9 Discussion of Locations Visited

The field survey across Oredo, Egor, and Ovia North-East revealed variations in both processing and storage practices, shaped by the urban–rural divide, available infrastructure, and level of investment. The analysis is presented under two main themes: processing and storage.

4.9.1 Processing

Processing facilities varied widely across the LGAs.

- **Oredo LGA:** Being urban and semi-urban, Oredo had both small-scale fish smoking units (traditional firewood kilns in Okhuoromi) and modern cold storage for frozen foods in Efehi. However, fish processors noted high costs of firewood and delays caused by inconsistent electricity, while cold room operators also battled unstable power supply and heavy fuel costs for backup generators.
- **Egor LGA:** In Uselu Market, processing was minimal—mostly vendors sprinkling water on peppers and tomatoes to prolong freshness. In Adolor, processors relied on traditional methods for groundnut cleaning and bagging. These approaches are simple but inadequate, leading to spoilage and low value addition.
- **Ovia North-East LGA:** Eguavoen and other rural areas focused on cassava, cucumber, and watermelon. Cassava was processed into garri using semi-mechanized facilities (diesel graters, hydraulic presses) alongside manual roasting. Respondents cited land space limitations and lack of access to loans as key challenges preventing expansion.
- **NIFOR (Ovia North-East):** The institute provided the most modern processing technologies, including clarifiers, sterilizers, and digester screw presses. However, even here electricity outages limited optimal performance, revealing that infrastructural challenges cut across both traditional and modern facilities.
- **Solar Dryer (field observation):** A solar dryer was observed being used for vegetable preservation. Farmers noted that it improved product hygiene and quality compared to open-air drying, but access was limited due to cost and lack of awareness.

Processing Challenges:

Table 4.8: Problems Encountered in Processing

Problem	Encountered? (Yes/No)
Limited Land Space (Cassava)	Yes

Lack of Funding/Government Support	Yes
Inconsistent Power Supply (Fish, Cassava)	Yes
High Cost of Firewood	Yes

- **Land space limitations:** Cassava processors reported that small landholdings constrained their capacity to process larger volumes, reducing efficiency and profitability.
- **Lack of funding:** Access to affordable credit and government support was scarce. This restricted adoption of advanced equipment, echoing findings by Adejumo & Raji (2020).
- **Inconsistent power supply:** Electricity disruptions affected fish smoking (delays in cleaning and packaging) and cassava grinding (machines stalled). Even NIFOR, with advanced equipment, cited unstable electricity as a bottleneck, forcing reliance on costly generators.
- **High cost of firewood:** Fish processors particularly lamented rising firewood prices, which escalated production costs and reduced profit margins. This problem also contributes to environmental degradation through deforestation.
- **Limited access to solar dryers:** While solar dryers improved product hygiene and reduced spoilage, farmers noted that very few units were available. High installation costs and lack of training limited wider adoption among smallholders.



Figure 4.33: Workers peeling cassava in a cramped space, illustrating land and space constraints faced during processing

4.9.2 Storage

Storage practices also reflected this rural–urban gradient.

- **Oredo LGA:** Cold rooms in Efehi stored frozen foods using compressors and condensers, but operators reported cold chain breakdowns during power outages. Watermelon sellers in Okhuoromi relied on ventilated sheds with soft padding to minimize bruising.
- **Egor LGA:** Groundnuts were stored in woven bags stacked on raised wooden platforms. This method was practical but prone to weevils and mould, especially during the rainy season. Market traders in Uselu shaded unsold peppers and tomatoes, a very rudimentary method that offered minimal preservation.
- **Ovia North-East LGA:** Farmers stored watermelon and cucumber in short-term facilities, often just ventilated rooms or simple bag padding. Cassava, once processed into garri, was stored in sacks in dry spaces. Silos were also observed as a modern facility for grains, providing bulk storage and longer shelf life, but respondents stressed that silos were limited to institutional use and out of reach for smallholder farmers.

Table 4.9: Problems Encountered in Storage

Problem	Encountered? (Yes/No)
Pest Infestation (Groundnut)	Yes
Moisture/Mould Damage (Groundnut)	Yes
Transportation Issues (Cucumber, Frozen Foods, Watermelon)	Yes
Unstable Power Supply (Cold Room)	Yes



Figure 4.34: Rotten groundnuts damaged by weevils during storage, showing the impact of pest infestation on quality and quantity (Source: Krishisewa 2023)

Storage Challenges

- **Pest infestation and mould:** Groundnut storage in bags was highly susceptible to weevils and fungal growth during the rainy season. This reduces both quality and market value.
- **Transportation issues:** Farmers of cucumber and watermelon highlighted high losses during transit due to bad roads. Approximately 3–5% of goods were lost before reaching markets.
- **Cold chain breakdowns:** Cold rooms in Oredo experienced frequent disruptions due to unstable electricity, raising operational costs and threatening product quality.



Figure 4.35: Bad rural road with trucks carrying agricultural produce, highlighting transportation difficulties that contribute to post-harvest losses (Source: Pinterest, 2023).



Figure 4.36: Modern silo facility observed during fieldwork, used for large-scale grain storage and protection against pests and moisture.

4.9.3 Synthesis of Processing and Storage Challenges

Across the three LGAs studied, a pattern of interconnected challenges emerged that cut across both processing and storage activities. In cassava processing, land space limitations reduced the scale of production and restricted efficiency. Lack of funding and government support further constrained access to mechanized equipment, leaving most operators dependent on traditional methods. Inconsistent power supply was one of the most disruptive barriers, affecting not only small-scale fish smokers and cassava graters but also modern processors such as NIFOR, who frequently resorted to costly generators.

The reliance on firewood for fish smoking and cassava roasting raised operational expenses while simultaneously driving environmental degradation through deforestation. On the storage side, pest infestation and mould were prevalent, especially in groundnut bags during the rainy season, reducing both quality and market value. Transportation issues, stemming from poor rural roads, resulted in 3–5% of perishable goods such as cucumbers, tomatoes, and watermelon being lost before reaching markets. Although modern facilities like cold rooms, silos, and solar dryers offered promising solutions, their adoption remained limited due to high costs and low accessibility for smallholder farmers.

These findings confirm that infrastructural weakness, financial exclusion, and environmental pressures form the backbone of post-harvest challenges in Benin City. While traditional systems remain dominant, their inefficiency and vulnerability underscore the urgent need for investment

in modern technologies, institutional support, and sustainable practices.

The results show that agricultural processing and storage in Benin City remain dominated by traditional methods, with only isolated use of modern facilities such as cold rooms, silos, and solar dryers. Persistent challenges, ranging from poor infrastructure and inadequate funding to unstable power supply and environmental pressures, continue to limit efficiency and value addition. These findings set the stage for the recommendations in the next chapter, which focus on practical strategies to strengthen post-harvest systems in the study area.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

This research focused on assessing processing and storage facilities in selected Local Government Areas of Benin City; **Oredo, Egor, and Ovia North-East**, with an additional institutional case study at the **Nigerian Institute for Oil Palm Research (NIFOR)**. The study set out to identify the types of facilities used in agricultural processing and storage, determine the level of mechanization, and examine the challenges encountered by farmers, processors, and traders in maintaining post-harvest quality. Through field surveys, questionnaires, and direct observation, the study provided a comprehensive understanding of the state of agricultural processing and storage in Benin City's food value chain.

The findings revealed a dominance of traditional and semi-mechanized methods across all three LGAs. These techniques, though cost-effective and accessible to small-scale operators, remain inefficient and prone to high post-harvest losses. Common examples included the use of firewood smoking kilns for fish, manual peeling and roasting of cassava, shade preservation and sprinkling for tomatoes and peppers, and bag storage for groundnuts. These traditional systems require significant manual labour, yield inconsistent product quality, and often expose produce to contamination and spoilage.

In contrast, semi-mechanized systems were observed in cassava garri production, where processors employed diesel-powered graters and hydraulic presses to improve output and reduce drudgery. However, these machines were locally fabricated, small in capacity, and frequently broke down due to poor maintenance and unreliable electricity. Similarly, the use of cold rooms for frozen food storage in Oredo LGA marked one of the few instances of advanced mechanization, but operational costs remained high because of fuel expenses and unstable power supply.

At the institutional level, **NIFOR** stood out as the most advanced facility within the study area. Equipped with clarifiers, sterilizers, digester screw presses, and full bunch strippers, the institute represents modern processing technology that ensures high efficiency, minimal losses, and better product quality. Yet, even at NIFOR, electricity instability was cited as a recurring issue affecting the continuous operation of equipment, indicating that infrastructural

challenges cut across all scales of production. The research also identified two additional modern innovations: **solar dryers** and **silos**, which were observed during fieldwork. These facilities demonstrated high efficiency in preserving perishable goods and grains respectively, reducing losses compared to traditional open-air drying and bag storage. However, their adoption remained limited, primarily because of high installation costs, low awareness among local farmers, and inadequate government support.

Across the three LGAs, the nature of agricultural activity followed an urban–rural gradient.

- **Oredo LGA**, being the commercial center, hosted small-to-medium-scale enterprises such as fish smoking, cold storage, and fruit vending, yet struggled with high operational costs and unstable electricity.
- **Egor LGA** was characterized by traditional, market-based preservation practices, especially among tomato, pepper, and groundnut traders.
- **Ovia North-East LGA** emerged as the rural production hub, where cassava, cucumber, and watermelon farming dominated. Here, land space limitations, poor infrastructure, and lack of financial access restricted expansion and efficiency.

A detailed analysis of respondents’ demographics showed that the sector is driven primarily by youths aged 25 - 40, indicating active but under-supported participation. Most respondents held SSCE qualifications, with only a few possessing tertiary degrees. This educational imbalance explained the low rate of mechanization and innovation adoption among smallholders. Gender participation was relatively balanced, with women dominating small-scale processing (fish smoking, tomato vending) while men were more active in mechanized operations and large-scale farming.

The major constraints identified include:

- Inconsistent power supply, disrupting both processing and cold storage.
- Lack of funding and government support, limiting access to modern machinery.
- High cost of firewood and fuel, increasing production expenses.
- Pest infestation and mould in stored products, particularly groundnuts.

- Transportation difficulties, with bad roads causing losses of up to 5% of perishable goods during distribution.
- Limited access to modern technologies, such as solar dryers and silos.

These recurring issues align with the reports of the Food and Agriculture Organization (FAO, 2023), which identified poor infrastructure, unstable power, and inadequate cold storage facilities as key drivers of post-harvest losses in Nigeria. Despite isolated progress in certain facilities, the study concludes that Benin City's agricultural sector remains largely traditional, with modernization happening slowly and unevenly.

In summary, the research established that while Benin City possesses significant agricultural potential, its processing and storage systems are constrained by financial, infrastructural, and technical limitations. There is a visible gap between institutional excellence (as seen at NIFOR) and smallholder struggles, emphasizing the need for stronger government support, improved infrastructure, and inclusive access to technology.

5.2 Conclusion

This study has shown that agricultural processing and storage in Benin City remain heavily dominated by traditional and semi-mechanized systems, despite the city's strategic position as a major food hub in Edo State. While efforts toward modernization are visible in certain facilities such as NIFOR, cold rooms, solar dryers, and silos, the overall level of technological adoption across Oredo, Egor, and Ovia North-East Local Government Areas remains low. The result is a system that functions, but inefficiently, one that preserves livelihoods but limits large-scale productivity and economic growth.

The evidence gathered from the field points to a recurring theme: the gap between potential and performance. Smallholder processors and traders are willing and able to engage in value addition, but they are constrained by limited access to finance, unreliable electricity, and poor road infrastructure. Traditional methods like firewood smoking, bag storage, and water sprinkling persist not because they are preferred, but because they are the only affordable options available to low-income operators.

The study also revealed that the benefits of modernization are undeniable. In facilities where advanced technologies were available, such as at NIFOR's oil palm processing unit, or in cold rooms equipped with compressors and condensers, product quality improved significantly,

losses were minimized, and production became more efficient. Similarly, the introduction of solar dryers and silos during field observation demonstrated that simple technological upgrades can dramatically reduce post-harvest losses and improve food hygiene. However, these facilities remain scarce, often concentrated in institutional or privately financed settings, leaving the majority of smallholders excluded.

Another important conclusion from the study is the **central role of human capital**. The findings indicated that most respondents had only basic education, with limited exposure to modern agricultural practices or technical training. This lack of knowledge contributes to poor equipment handling, low maintenance culture, and minimal innovation. Gender inclusion was positive, but female processors, who dominate small-scale food preservation, remain under-supported in terms of credit and capacity-building programs.

Environmental sustainability also emerged as a subtle but significant issue. The high dependence on firewood for fish smoking and cassava roasting not only drives up production costs but also contributes to deforestation and carbon emissions. In the long term, this reliance on unsustainable energy sources threatens both the environment and the viability of traditional livelihoods.

Overall, the research concludes that the agricultural processing and storage landscape in Benin City reflects a microcosm of Nigeria's wider agricultural challenges, where innovation exists but is unevenly distributed; where policy intentions are strong but implementation is weak; and where the drive of smallholder farmers is undermined by systemic neglect. To bridge the gap between traditional and modern systems, there is an urgent need for integrated development strategies that address infrastructure, funding, and education simultaneously.

In essence, the path forward for Benin City's agricultural sector lies in empowering smallholders with access to affordable technology, promoting energy-efficient processing systems, improving rural infrastructure, and fostering partnerships between institutions like NIFOR and community-level producers. If these measures are implemented, the city could transition from a fragmented, traditional system to a model of sustainable agro-industrial growth that supports both economic advancement and food security.

5.3 Recommendations

Based on the findings and conclusions of this research, several key recommendations are proposed to improve the efficiency, sustainability, and profitability of agricultural processing and storage systems in Benin City. The recommendations are grouped under relevant stakeholders for clarity and actionability.

5.3.1 Government and Policy Makers

1. Provide Access to Affordable Credit and Grants:

Most small-scale processors and traders operate on tight budgets that prevent them from acquiring modern machinery or building improved storage facilities. The government should collaborate with microfinance institutions and agricultural banks to offer low-interest loans, grants, and subsidies for equipment such as cassava graters, solar dryers, and cold storage units.

2. Invest in Rural Infrastructure:

Poor Road networks were a recurring challenge, leading to post-harvest losses of 3– 5% for perishable produce. Strategic investment in feeder roads, bridges, and transport facilities would enhance produce movement from farms to markets and reduce spoilage during transit.

3. Strengthen Power Supply and Promote Renewable Energy:

Unstable electricity severely disrupted cold storage and mechanized processing operations. Expanding the rural electrification grid and supporting solar-powered equipment (e.g., solar dryers and solar refrigeration systems) can reduce dependence on fuel-powered generators and lower production costs.

4. Implement Targeted Mechanization Policies:

There should be deliberate government policies to promote local fabrication of agricultural machinery, with technical training and standardization support. Mechanization clusters could be developed in each LGA to ensure processors can rent or share equipment instead of individually purchasing expensive machines.

5. Encourage Environmental Sustainability:

The use of firewood for fish smoking and cassava roasting contributes to deforestation. Government agencies should support the transition to energy-efficient kilns and eco-friendly biomass alternatives, possibly through public-private partnerships.

5.3.2 Research and Institutional Bodies (e.g., NIFOR, Universities, Agricultural Research Centers)

1. Technology Transfer and Capacity Building:

Institutions like NIFOR should extend their technical expertise to local processors and farmers through training workshops, field demonstrations, and outreach programs. This will bridge the gap between research knowledge and field application.

2. Public - Private Collaboration:

Collaboration between research institutes and private agro-enterprises should be encouraged to develop low-cost, scalable technologies suitable for smallholder adoption, such as mini-solar dryers, compact silos, and improved fish smoking kilns.

3. Establishment of Community Processing Centers:

Setting up multi-crop processing hubs in each LGA would enable small-scale producers to access modern equipment collectively. These hubs could be managed by cooperatives under the supervision of local authorities or extension agents.

4. Research on Post-Harvest Innovations:

Continuous research should focus on improving storage materials, pest-resistant packaging, and humidity-controlled environments to extend product shelf life and maintain nutritional quality.

5.3.3 Farmers, Processors, and Traders

1. Adopt Improved and Hygienic Processing Methods:

Local processors should gradually shift from open-air drying and firewood smoking to solar drying, improved kilns, and mechanized graters/presses. Though the initial cost is high, cooperative ownership models can make it affordable and sustainable.

2. Promote Cooperative Societies:

Forming farmer–processor cooperatives will strengthen bargaining power, enable bulk purchasing of inputs, facilitate equipment sharing, and improve access to government support schemes and technical training.

3. Enhance Record Keeping and Maintenance Culture:

Many smallholders lack record-keeping practices that track costs, output, and losses. Training in simple bookkeeping and equipment maintenance will improve financial planning, reduce breakdowns, and extend the lifespan of machines.

4. Adopt Proper Storage and Packaging Practices:

Farmers should adopt aerated storage, moisture-resistant materials, and stacking techniques (e.g., raised pallets for groundnuts, padded surfaces for watermelons). For perishable crops, small-scale cold storage or solar-powered coolers could reduce spoilage.

5.3.4 Development Partners and NGOs

1. Support Technology Dissemination:

NGOs working in agricultural development can provide grants or demonstration units for solar dryers, silos, and improved packaging. These initiatives can help rural farmers test modern technologies before large-scale adoption.

2. Promote Training on Post-Harvest Management:

Capacity-building programs should focus on food safety, equipment operation, quality control, and market standards. Training women and youth specifically can enhance inclusive growth and economic empowerment.

3. Encourage Market Linkages:

Development partners should facilitate connections between smallholders and larger agribusinesses or export markets, helping farmers secure better prices for processed products and reduce dependence on middlemen.

5.3.5 Future Research Recommendations

1. Future studies should conduct comparative cost-benefit analyses of traditional versus mechanized systems to quantify economic advantages and payback periods.
2. Gender-based research should explore how men and women differ in processing roles, technology access, and decision-making.
3. Further research could also investigate the environmental impacts of firewood usage and the long-term benefits of adopting solar and biomass-based technologies.

This combination of technical, institutional, and policy recommendations reflects the multidimensional nature of the problem. Implementing them collectively will enhance agricultural productivity, reduce post-harvest losses, and promote sustainable, inclusive growth across Benin City's agricultural value chain.

5.4 Contribution to Knowledge

This study contributes to existing knowledge by providing an in-depth, location-based analysis of agricultural processing and storage systems in Benin City. Unlike previous research that focused broadly on Edo State, this work specifically examined the differences across Oredo, Egor, and Ovia North-East LGAs, highlighting how infrastructure, funding, and technology access shape post-harvest outcomes.

It also introduced practical documentation of both traditional and emerging facilities, including the role of solar dryers and silos, technologies rarely explored at the local level. By combining field observations with data from smallholders and institutions like NIFOR, the study bridges the gap between academic research and real-world agricultural practice.

Overall, this work provides a contextual framework that policymakers, extension agents, and development partners can rely on to design location-specific interventions for improving agricultural processing and storage in urban and peri-urban Nigeria.

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